Lecture 24:

We’ve made it through the Precambrian.

Now we’re in the Phanerozic: 544 Ma to present-day

Where we’re going:
- Review marker events in Earth history
  - Mesozoic (251-65 Ma) Warmth (p.245-251)
  - Cenozoic (65 Ma-present) Cooling
    - Pleistocene (2 Ma-present) glacial cycles (Chapter 14)
    - Climate of the last millennium (Chapter 15)

Weeks 8,9,10
- Climate of the 20th century
  - Global Warming: science and policy issues

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Earth History: Review of Marker Events
1. Origin of Earth 4.56 Ga
2. Origin of Life don’t know; some time before 3.8 Ga
3. First Rise of Oxygen First set of Snowball Earths 2.4-2.2 Ga
4. Second Rise of Oxygen Second set of Snowball Earths about 800-600 Ma
5. Ediacaran fossils Cambrian Explosion of fossils 575 Ma (perhaps as old as 590 Ma)
6. Biggest Animal Extinction 544 Ma
7. Asteroid extinction of dinosaurs 65 Ma
8. Beginning of modern glaciations/interglacials 2.5 Ma
9. End of last ice-age 12 ka

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How I remember all the geological ages

Camels only sit down carefully, Perhaps their joints are painful, Perhaps early oiling might prevent permanent hardening. = Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene, Holocene.

You don’t absolutely need to know this but it does help
### Mesozoic Warmth (251-65 Ma)

**The era of dinosaurs**

**Climate:**
- Warmer global-mean temperature.
- Much warmer Polar Regions; no ice-caps.
- Much warmer deep ocean: 15°C vs. 2°C today.

**Evidence:**
- Oxygen isotopes in oceanic carbonates.

**Cause:**
- Higher CO₂ is leading suspect.
- Sea-floor spreading rate was greater.
- Higher sea level (no ice caps): less land for weathering.

**Mesozoic climate mystery:**
The eq-to-pole temperature gradient was very small (above Fig). Somehow eq-to-pole heat transport was very efficient or the greenhouse effect was enhanced at the poles by high clouds.

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### Carbon isotopes as CO₂ indicators

Organisms preferentially take up ¹²C. But if CO₂ is low, photosynthesizers will extract whatever C atoms they can get, whether ¹²C or ¹³C. (a "beggars can’t be choosers" isotope rule)

At low CO₂ experiments show more ¹³C in organic matter than with abundant CO₂.

**Cenozoic cooling, 65 Ma to present**

**What:**
- Earth cools after 80 Ma.
- Life retreats from poles.
- Polar ice caps form.
- Eventually, ice-ages begin.

**Why (one leading theory):**
- Initial decrease due to slower midocean ridge spreading.
- Then India collides with Asia at 40-30 Ma.
- Himalayas form.
- Silicate weathering increases.
- Atmospheric CO₂ goes down.
Pleistocene (1.8 Ma-10 ka) glacial cycles

Maximum ice extent
(Seattle under 1 km of ice.)

Glacier indicators:
- striations,
- till / moraines
Also some of the till is fine silt (~0.01 mm)
and gets transported and deposited by the wind.
Deposits are called loess.

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Oxygen Isotopes: Evidence for Temperature

$^{16}O$ vs $^{18}O$

- evaporation favors "light" $^{16}O$
- condensation (precipitation) favors "heavy" $^{18}O$

Less $^{18}O$ in ice-cores indicates colder temperature:
Colder conditions mean more precipitation en route so isotopically
"lighter" snow (precipitation leaves water vapor for snow enriched in $^{16}O$)
More $^{18}O$ in ocean carbonates records glacial ice volume:
More $^{18}O$-enriched water in ice-sheets means remaining ocean is "heavier".
Questions:
1. Is this an ocean sediment record or a polar ice-core record?
   - Ocean sediments record ice volume. Ice-core records only extend back to about 500,000 years.

2. What two major transitions do you see in this record?
3. Was sea-level lower or higher than today during the three most prominent previous interglacial periods?
   - Less ice-volume, therefore higher sea level. (May have been warmer than today as well.)